# **Arbovirus Surveillance in Massachusetts 2016**

## Massachusetts Department of Public Health (MDPH)
## Arbovirus Surveillance Program

## INTRODUCTION

There are two mosquito-borne diseases of concern for transmission in Massachusetts, eastern equine encephalitis (EEE) virus, which was identified as a cause of human disease in 1938, and West Nile virus (WNV), which has been present in Massachusetts since 2000. Infection with EEE is a rare but serious neuroinvasive disease that causes meningitis or encephalitis, and often results in death or severe disability. Infection with WNV is more common, though typically less severe than infection with EEE; presentation of WNV infection ranges from febrile illness to neuroinvasive disease. Although up to 51 different species of mosquitoes have been identified in Massachusetts, only a few of these contribute to either WNV or EEE spread. For more information, visit the MDPH website to view Common Mosquitoes That Can Spread Disease in Massachusetts.

Currently there are no available vaccines to prevent human infections from either mosquito-borne virus. Personal protection measures that serve to reduce exposure to mosquitoes and thereby prevent human infection remain the mainstays of prevention. To estimate the risk of human disease during a mosquito season, the MDPH, in cooperation with the local Mosquito Control Projects, conducts surveillance for EEE and WNV using mosquito samples, and specimens from human and veterinary sources. Detailed information about surveillance for these diseases in Massachusetts is available on the MDPH website at Arbovirus Surveillance and Control Plan.

## EASTERN EQUINE ENCEPHALITIS VIRUS

### Humans

There were no human cases of EEE virus infection identified in Massachusetts in 2016 or 2015.

### Mosquito Samples

Of 6,414 mosquito samples collected in Massachusetts in 2016, four samples (0.1%) were positive for EEE virus in 2016. The positive samples were identified in the towns of Kingston and Middleborough, West Bridgewater, and Yarmouth. For a complete list of positive mosquito samples by city/town, please see the 2016 Mosquito Summary by County and Municipality report posted on the MDPH website.

### Animals

Four veterinary samples were submitted for arbovirus testing. There were no animals that tested positive for EEE virus infection in 2016.

### Birds

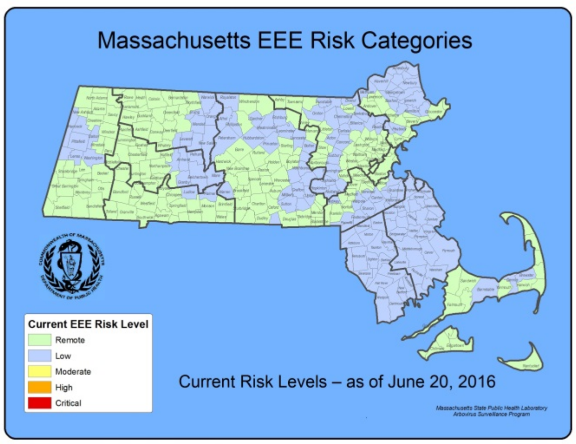
Although birds are not routinely tested as part of EEE surveillance, species such as emus or exotic quail may experience sudden illness and mortality due to EEE. Farmed birds showing these signs must be reported promptly to the Massachusetts Department of Agricultural Resources (MDAR).

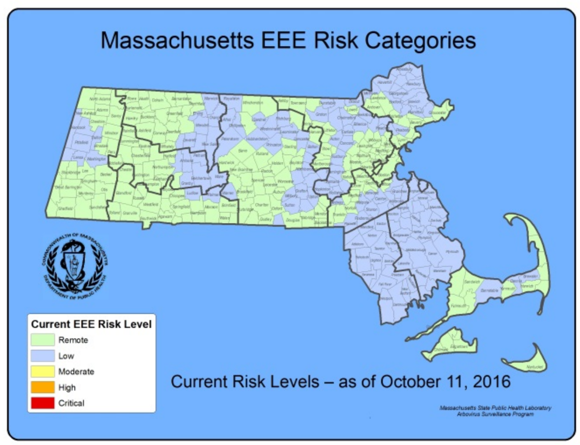
### EEE Geographic Risk Levels

EEE risk maps combine historical data and areas of mosquito vector habitat with current data on positive virus isolations (in humans, mosquitoes, etc.) and weather conditions. Risk levels are an estimate of the likelihood of an outbreak of human disease and are updated weekly based on the most current surveillance data. Initial and final EEE risk levels from the 2016 season are provided in the following maps. This information will be used to help anticipate risk in 2017 and will be revised as 2017 surveillance data are collected. More detailed information about risk assessment and risk levels is available in the Arbovirus Surveillance and Response Plan on the MDPH web site.

**Initial and Final 2016 EEE Risk Categories**

(As defined in Table 2 of the MDPH Arbovirus Surveillance and Response Plan which can be found at www.mass.gov/dph/mosquito under "Surveillance Summaries and Data")

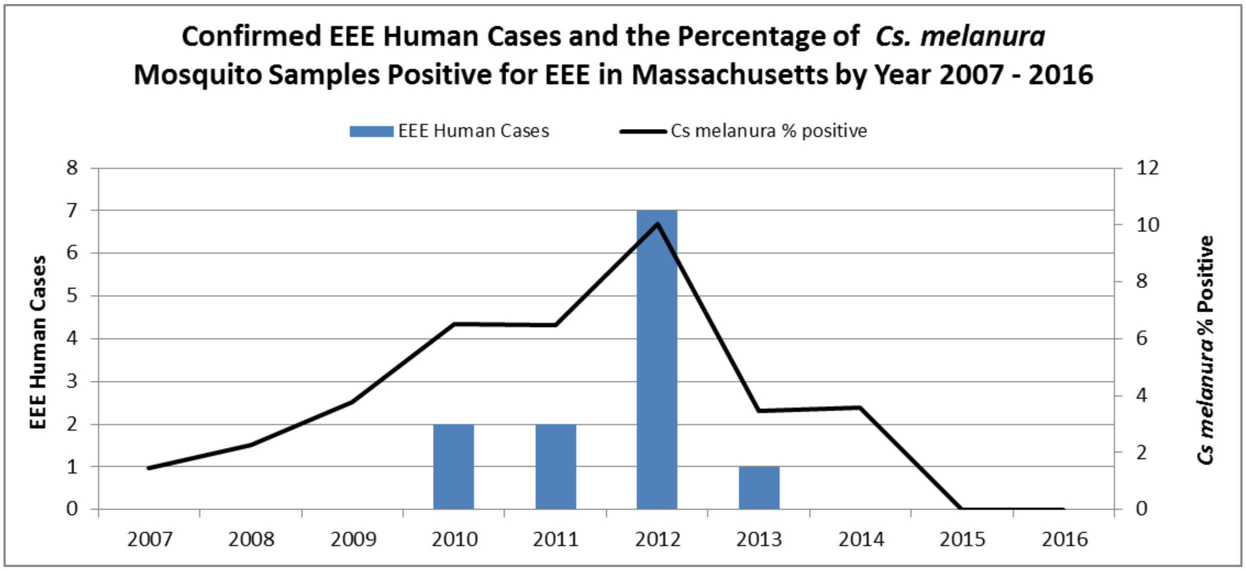



## 2016 EEE SEASON DISCUSSION

There were no confirmed human EEE cases in 2016 or 2015, compared to seven confirmed human cases in 2012; 2012 was the most recent outbreak year in Massachusetts. The number of confirmed human cases nationwide was lower in 2016 (five) and 2015 (five) when compared to 2012 (15).

There were also fewer EEE virus positive mosquito samples in Massachusetts in 2016 (four) than there were in 2012 (267). In 2016, MDPH identified zero EEE positive samples of *Culiseta melanura,* the enzootic vector of EEE. Mosquito surveillance activities are highly adaptive to identifications of EEE virus, with more mosquito trapping and testing in years when EEE activity is increased, this makes year-to-year comparisons somewhat difficult. In general, years with increased EEE human infections are associated with an increase in the percentage of *Cs. melanura* samples positive for EEE virus (see figure below).

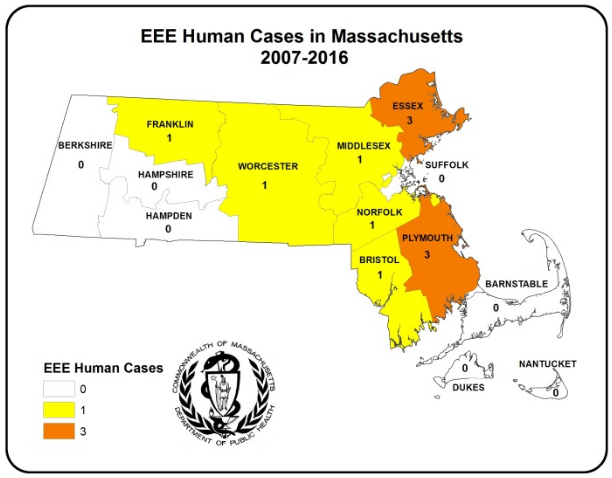



**Why was there less EEE activity in 2013 - 2016 than in 2012?**

Historically, EEE outbreak periods have rarely lasted more than three years, although evidence suggests that previously observed patterns may be changing and the situation must be monitored carefully. Intense EEE activity associated with outbreaks of human disease occurred in 2004-2006 and 2010-2012. Outbreak potential is probably supported, in part, by previously unexposed populations of birds that are susceptible to EEE virus infection and therefore capable of maintaining the cycle of virus transmission. After three years (2010-2012) of intense virus activity, the population of susceptible birds may not have been adequate to maintain the virus cycle in more recent years. Current research also suggests that each of these cycles is associated with the introduction of a new strain of EEE virus by migratory birds.. Other important factors impacting EEE virus cycles include large *Cs. melanura* mosquito populations which are more likely to support significant EEE activity, and weather conditions such as significant precipitation events and prolonged periods of higher temperature.

In 2012, significant precipitation and prolonged periods of high temperature provided favorable conditions for mosquito development. In 2013, the mosquito season began with above-average precipitation, but precipitation declined midway through the season and cooler evening temperatures occurred during prime transmission season, causing a delay in development of new mosquitoes. In 2014, limited spring and summer precipitation produced similar declines in the numbers of new mosquitoes. In 2015, the mosquito season began with significant snowmelt, but precipitation declined early in the season with few significant precipitation events in the summer or fall. This led to loss of breeding habitat for mosquitos throughout the season with below average abundance rates. In 2016, below average precipitation in winter, spring, and summer, combined with above average summer temperatures, reduced available breeding habitat for the traditional vectors of EEE and led to below average mosquito abundance rates throughout the breeding season.

In Massachusetts, *Culiseta melanura* activity is important for EEE virus amplification while mammal-biting mosquitoes, such as *Coquillettidia perturbans*, serve to spread the virus to humans. The map to the right illustrates the distribution of human cases over the last 10 years. Southeastern Massachusetts has been the historic area of risk and continues to be a high risk area; Essex county has had recent, more unusual activity.




**Variability in Geographic Range of EEE**

In Massachusetts over the last ten years, some human EEE cases have occurred outside of the historic area of risk and there have been year-to-year variations in the geographic pattern of disease occurrence. This is not unique to Massachusetts; during 2012-2016, human cases of EEE were reported from neighboring states including Connecticut, Maine, New Hampshire, New York, Rhode Island, and Vermont. Many of these cases were unusual in that they occurred in: states which rarely see EEE cases (Connecticut and Rhode Island); states where EEE cases are a very recent occurrence (Maine, New Hampshire and Vermont); and in unusual areas in states that have historic areas of risk (New York). MDPH continues to perform adaptive surveillance activities to provide for early detection of EEE throughout the Commonwealth.

**What are the expectations for EEE in 2017?**

Mosquito abundance and vector-borne disease risk are affected by multiple environmental factors which vary over time and geographic location. The two most important contributors to mosquito development are precipitation and temperature. All species of mosquito depend on the presence of water for the first stages of life. Mosquito populations increase when water is plentiful and decrease during dry periods. Warmer temperatures shorten both the time it takes for mosquitoes to develop from egg to adult and the time it takes for a mosquito to be able to transmit a pathogen after ingesting an infected blood meal.

The summer and fall of 2016 was warmer but much drier than average which reduced the breeding habitat available for the traditional vectors of EEE and early reports from the field indicate below average numbers of juvenile *Cs. melanura.* A preliminary assessment of the winter of 2016-2017 has demonstrated warmer than average temperatures combined with significant precipitation events; this does not increase the number of currently over-wintering juvenile mosquitoes, but may provide a better breeding habitat in the spring.

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Mosquito populations alone are not sufficient to produce significant EEE risk; infected birds are also necessary. Unfortunately, less is known about the factors that lead to large numbers of infected birds, making this component of risk impossible to use in predictions. At this time there is no efficient method to conduct surveillance for infection levels in wild birds.

Both the variability of New England weather and the inability to detect EEE virus infection levels in wild bird populations require that Massachusetts maintain a robust surveillance system to detect EEE virus in mosquitoes as a tool to assess risk for human disease.

## WEST NILE VIRUS

### Humans

There were 16 human cases of WNV infection identified in Massachusetts in 2016. The results are summarized in the table below.

| County | Age Range | Onset Date | Virus Result | Clinical Presentation |
|---|---|---|---|---|
| Middlesex | 71-80 | 7/26/2016 | WNV | MENINGITIS |
| Franklin | 51-60 | 8/9/2016 | WNV | FEVER |
| Norfolk | 41-50 | 8/19/2016 | WNV | FEVER |
| Suffolk | 71-80 | 8/24/2016 | WNV | MENINGOENCEPHALITIS |
| Middlesex | 81-90 | 8/25/2016 | WNV | ENCEPHALITIS |
| Norfolk | 71-80 | 8/28/2016 | WNV | ENCEPHALITIS |
| Essex | 41-50 | 9/2/2016 | WNV | FEVER |
| Middlesex | 61-70 | 9/4/2016 | WNV | FEVER |
| Middlesex | 81-90 | 9/5/2016 | WNV | ENCEPHALITIS |
| Middlesex | 71-80 | 9/8/2016 | WNV | FEVER |
| Middlesex | 71-80 | 9/9/2016 | WNV | ENCEPHALITIS |
| Middlesex | 51-60 | 9/15/2016 | WNV | MENINGITIS |
| Middlesex | 51-60 | 9/18/2016 | WNV | FEVER |
| Middlesex | 31-40 | 9/26/2016 | WNV | MENINGITIS |
| Middlesex | 71-80 | 9/28/2016 | WNV | ENCEPHALITIS |
| Middlesex | 21-30 | 10/6/2016 | WNV | MENINGOENCEPHALITIS |

### Presumptive Viremic Blood Donors

WNV is transmissible through blood transfusion. Since June 2003, blood banks have screened donated blood for WNV using a nucleic acid test (NAT) that identifies viral genetic material. Positive units are not used and donors are deferred from future donation for 120 days. The AABB (formerly the American Association of Blood Banks) notifies MDPH of any presumptive viremic donors (PVDs), i.e., individuals whose donated blood tests positive using the NAT test and the blood collection center reports the laboratory result. MDPH performs case investigations on all PVDs and uses that information to assist in geographic assessments of risk.

There were three PVDs identified in Massachusetts in 2016. The number of PVDs nationwide was down in 2016 (275) from 2015 (345).

| County | Donation Date | Virus Result |
|---|---|---|
| Plymouth | 7/30/2016 | WNV |
| Middlesex | 9/11/2016 | WNV |
| Middlesex | 9/20/2016 | WNV |

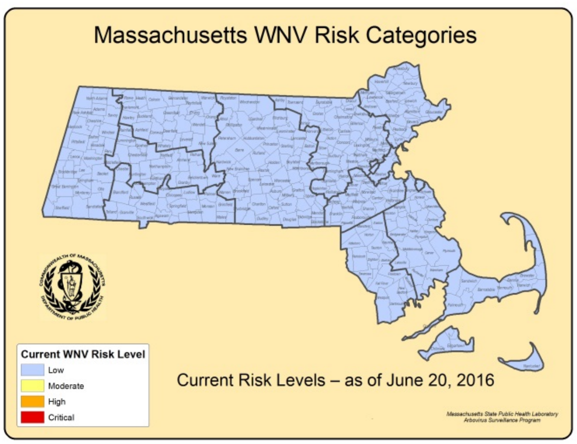
### Mosquito Samples

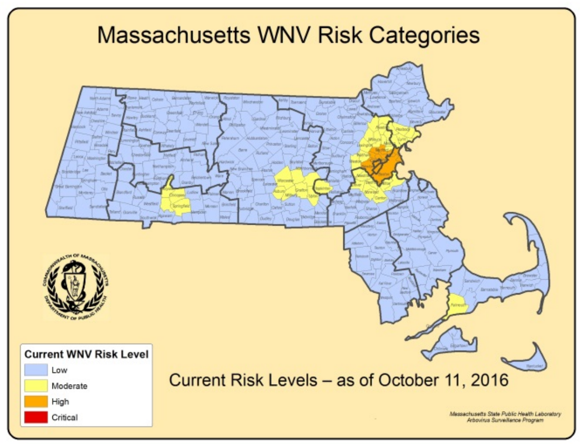
Of 6,414 mosquito samples collected in Massachusetts in 2016, 189 (2.9%) were positive for WNV. Positive mosquito samples included 185 (98%) *Culex* species. Positive samples were identified in 70 towns in 11 counties. For a complete list of positive mosquito samples by city/town, please see the 2016 Mosquito Summary by County and Municipality report posted on the MDPH website.

**Animals**
Four veterinary samples were submitted for arbovirus testing. There were no animals that tested positive for WNV in 2016.

**WNV Geographic Risk Levels**
WNV risk maps are produced by integrating historical data and areas of mosquito habitat with current data on positive virus identifications (in humans, mosquitoes, etc.) and weather conditions. Risk levels serve as a relative measure of the likelihood of an outbreak of human disease and are updated weekly based on that week's surveillance data. Initial and final WNV risk levels from the 2016 season are provided in the following maps. This information will be used to help predict risk in 2017, and will be revised as 2017 surveillance data are collected. More detailed information about risk assessment and risk levels is available in the Arbovirus Surveillance and Response Plan on the MDPH web site during the arbovirus season.

**Initial and Final 2016 WNV Risk Categories**
(As described in Table 1 of the MDPH Arbovirus Surveillance and Response Plan which can be found at www.mass.gov/dph/mosquito under "Surveillance Summaries and Data")



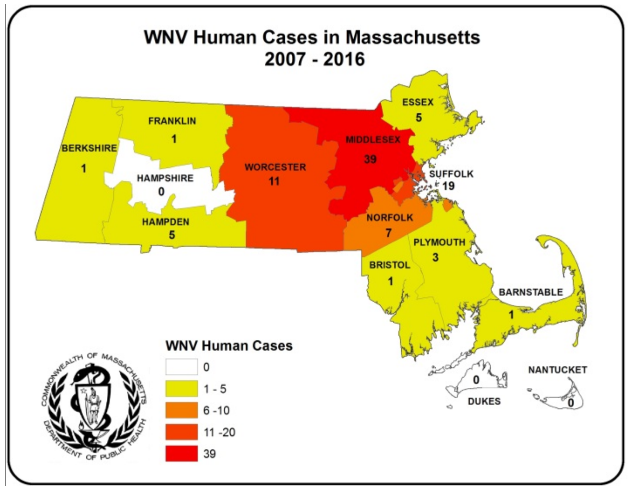




## 2016 WNV SEASON DISCUSSION

MDPH identified 16 confirmed human WNV infections in 2016 compared to 10 confirmed cases in 2015. The number of confirmed human cases nationwide in 2016 (2,038) was slightly less than in 2015 (2,175), but far fewer than the 2012 outbreak (5,674).

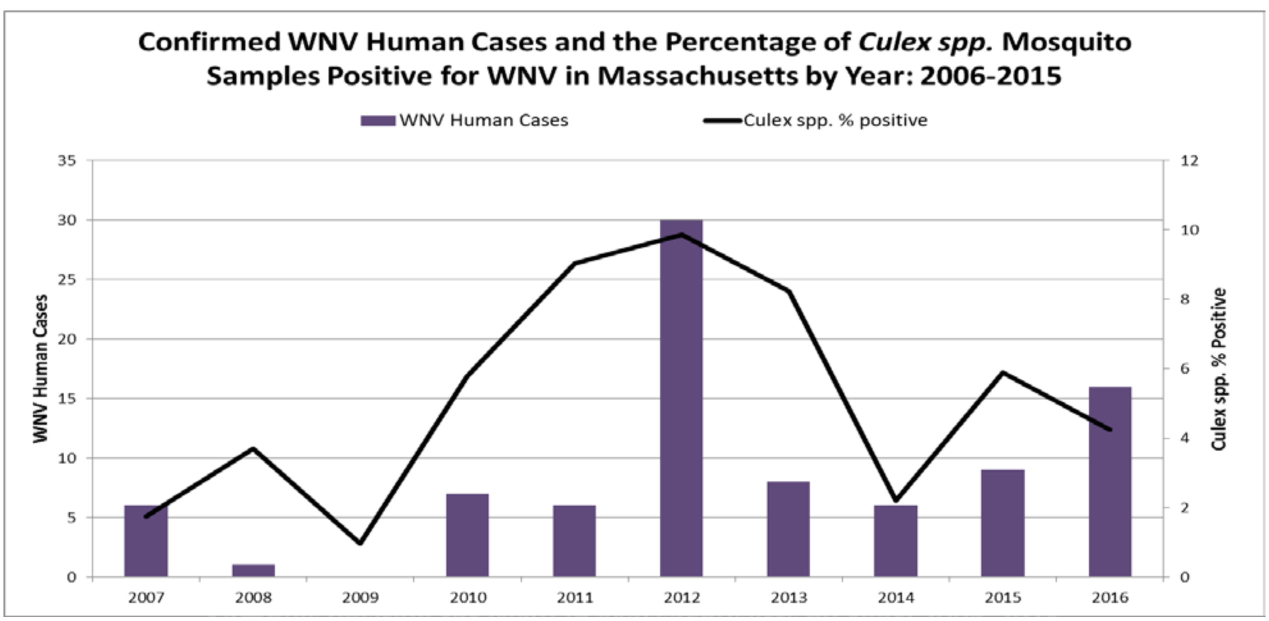
Of the 2,038 cases identified nationally in 2016, 1,140 (56%) were classified as neuroinvasive disease (such as meningitis or encephalitis) and 898 (44%) were classified as non-neuroinvasive disease. The majority of the cases were reported from four states (California, Illinois, South Dakota, and Texas). 21% of all cases were reported from California.

In Massachusetts, the vectors for WNV are primarily *Culex* species. *Culex* species are closely associated with human activity. The map to the right illustrates that transmission to humans is highest in counties with high population densities.




## WNV Mosquito & Human Disease Correlation

In 2016, MDPH identified 185 WNV positive *Culex* species mosquito samples as compared to 160 WNV positive *Culex* species mosquito samples in 2015. In general, years with increased WNV human infections are associated with an increase in the percentage of *Culex* samples positive for WNV (see figure below). Considering the increase in human cases of WNV infection that occurred from 2014-2016, an increase in WNV positive mosquito samples might be expected. As the graph below demonstrates, the percentage of WNV positive *Culex* mosquito samples decreased sharply from a peak in 2012, associated with a notably hot summer and a national outbreak, to a low in 2014 with an uptick in 2015 and 2016.



**What are the expectations for WNV in 2017?**

The primary determinants of human WNV disease risk during any particular season are populations of *Culex* mosquito species and the presence of infected birds. The two most important variables for mosquito development are precipitation and temperature. Warmer temperatures shorten both the time it takes for mosquitoes to develop from egg to adult and the time it takes for a mosquito to be able to transmit a pathogen after ingesting an infected blood meal. *Culex* mosquito populations tend to be greatest during seasons with periodic precipitation events (giving rise to stagnant puddles that favor *Culex* breeding).separated by hot, dry days

Mosquito populations alone are not sufficient to produce significant WNV risk; infected birds are also necessary. Unfortunately, less is known about the factors that lead to large numbers of infected birds, making this component of risk impossible to use in prediction and there is no efficient way to conduct surveillance for infection levels in wild birds.

The lack of useful pre-season predictive factors limits the ability of MDPH to make any accurate assessments regarding future WNV activity. Both the variability of New England weather, and the inability to detect WNV infection levels in wild bird populations, requires that Massachusetts maintain a robust surveillance system to detect WNV in mosquitoes as a primary tool to assess risk for human disease. MDPH continues to strive to identify reliable measures to aid in risk assessments.

## Invasive Mosquito Species Surveillance

MDPH and its partners are taking proactive measures to conduct surveillance for invasive mosquito species, especially *Aedes albopictus*, which is expanding its geographic range northward. *Ae. albopictus* was introduced to North America from Asia around 1985. It has been implicated in the transmission of arboviruses, such as dengue, chikungunya, yellow fever, and Zika, where these viruses circulate. These mosquitoes are aggressive biters that actively seek out mammals, including humans, during daytime hours, making them both a nuisance and a vector species. Where it occurs, this species is generally more abundant in urban areas, breeding in artificial containers, such as birdbaths, discarded tires, buckets, clogged gutters, catch basins, and other standing water sources.

Limited detections of *Ae. albopictus* were first identified in Southeastern MA in 2009. Since then, additional observations have been made and some evidence of *Ae. albopictus* activity has now been detected in 10 communities throughout the state. Evidence of established populations remains limited and localized, but also suggests that the mosquito species is successfully moving into Massachusetts.

MDPH, in collaboration with the Mosquito Control Projects, will continue to conduct routine surveillance activities to monitor for the presence and expansion of *Ae. albopictus* and other invasive mosquito species.